Choroidal vascularity index (CVI) – a novel biomarker

CVI is defined as the percentage of total choroidal area that is vascular. It is believed to be more accurate and repeatable than existing parameters such as choroidal thickness (CT).

CVI is computed using our own protocol, by segmenting and binarizing OCT images using the public domain software, Fiji ImageJ (http://imageJ.nih.gov/ij/). A fully automated software is currently being developed by our group.

Since its proposal in the letter to the editor of American Journal of Ophthalmology in 2016, CVI has become a widely accepted research tool, with consistent findings leading to over 40 publications in peer reviewed journals. CVI has the potential as a practical tool for monitoring, diagnosing and prognosticating ocular diseases, with significant implications on clinicians' therapeutic decision making

CVIgrid – a global research consortium

CVIgrid was established in 2018 as a common platform connecting like-minded researchers worldwide. We aim to validate CVI and produce more high impact publications through multi-national collaborative studies, driving forward choroidal research for many years to come.

Members will have access to cvigrid.org, an online database for OCT image and data sharing. Researchers will be able to initiate new projects and offer collaboration for existing projects under CVIgrid.

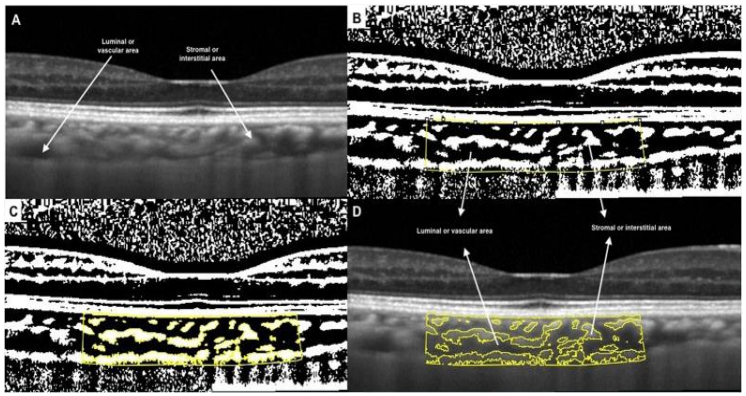
Currently, CVIgrid has 18 partnering institutions from 10 countries.

CVI landmark study

Population-based study on 345 healthy eyes.

Choroidal EDI-OCT were segmented into total subfoveal choroidal area (TCA), vascular luminal (LA) and stromal (SA) area. CVI was calculated as the proportion of LA to TCA.

Subfoveal CVI	Range: 60.07 to 71.27% Mean: 65.61 ± 2.33%. CVI was less variable than subfoveal CT (SFCT). While SFCT was affected by many factors, CVI remained unaffected by most physiological variables, suggesting CVI to be a more robust marker of choroidal diseases.



(A) Original SD OCT image.

(B) 1.5 mm segmentation block of the subfoveal choroidal area.

(C) Segmented OCT image using modified image binarization approach.

(D) Overlay of region of interest created after image binarization was performed on the SD OCT image.

Agrawal, R. et al. ***Choroidal vascularity index as a measure of vascular status of the choroid: Measurements in healthy eyes from a population-based study.*** Sci. Rep. ***6****, 21090; doi: 10.1038/srep21090 (2016).*

CVIgrid
Collaborate. Contribute. Create impact.

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Adjunct Associate Professor Rupesh Agrawal
Senior Consultant Ophthalmologist
National Healthcare Group Eye Institute
Tan Tock Seng Hospital, Singapore

Honorary Consultant, Moorfields Eye Hospital, London, UK
Adj Assc Professor, School of MSE, Nanyang Technological University, Singapore
Adjunct Research Faculty, Singapore Eye Research Institute
Clinical Senior Lecturer, Yong Loo Lin School of Medicine, National University of Singapore

Interested collaborators please contact
rupeshttsh@gmail.com

National Healthcare Group EYE INSTITUTE
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Publications on CVI

Currently, there are more than 40 existing publications on CVI, obtainable via Google Scholar or PubMed search. This brochure provides a non-comprehensive coverage of CVI research, presenting only several notable studies in this field.

CVI in systemic diseases

Diabetes Mellitus Tan, K. , Laude, A. , Yip, V. , Loo, E. , Wong, E. P. and Agrawal, R. (2016), **Choroidal vascularity index – a novel optical coherence tomography parameter for disease monitoring in diabetes mellitus?.** Acta Ophthalmol, 94: e612-e616. doi:10.1111/aos.13044	Eyes of patients with DM showed decreased CVI with no corresponding change in choroidal thickness. Image binarization may be potentially useful as a tool to assess choroidal structures and vasculature.
Juvenile systemic Lupus Erythematosus Ağın, A., Kadayıfçılar, S., Sönmez, H. E., Baytaroğlu, A., Demir, S., Sağ, E., … Eldem, B. (2019). **Evaluation of Choroidal Thickness, Choroidal Vascularity Index and Peripapillary Retinal Nerve Fiber Layer in Patients with Juvenile Systemic Lupus Erythematosus.** *Lupus*, *28*(1), 44–50. https://doi.org/10.1177/0961203318814196	Choroidal thickness at five points, total choroidal area, luminal area and stromal were found to be higher in patients with jSLE, whereas retinal nerve fiber layer thickness and CVI were similar to those of the healthy control individuals.

CVI in ocular diseases

Age related macular degeneration Wei X, Ting DSW, Ng WY, Khandelwal N, Agrawal R, Cheung CMG. **Choroidal Vascularity index: A Novel Optical Coherence Tomography Based Parameter in Patients With Exudative Age-Related Macular Degeneration.** *Retina.* 2017 Jun;37(6):1120-1125. doi: 10.1097/IAE.0000000000001312	Eyes with exudative AMD demonstrated reduced choroidal vascularity index but insignificant differences in choroidal thickness compared with their fellow eyes. Choroidal vascularity index may be a potential noninvasive tool for studying structural changes in choroid and monitoring choroidal disease in exudative AMD.
Central serous chorioretinopathy Agrawal R, Chhablani J, Tan KA, Shah S, Sarvaiya C, Banker A. CHOROIDAL VASCULARITY INDEX IN CENTRAL SEROUS CHORIORETINOPATHY. Retina. 2016 Sep; 36(9): 1646-1651(6) DOI: https://doi.org/10.1097/IAE.0000000000001040	Increased CVI suggests increased vascular component compared with the stromal component in acute CSC. Increased CVI was noted in fellow eye of the subjects with acute CSC in comparison with age-matched healthy subjects. The CVI could be a useful index for early diagnosis of CSC and to assess the treatment response after laser photocoagulation or photodynamic therapy.

CVI in monitoring treatment response

Response to corticosteroids in tubercular multifocal serpiginoid choroiditis Agarwal A, Agrawal R, Khandelwal N, Invernizzi A, Aggarwal K, Sharma A, Singh R, Bansal R, Sharma K, Singh N, Gupta V. **Choroidal Structural Changes in Tubercular Multifocal Serpiginoid Choroiditis.** *Ocul Immunol Inflamm*. 2017 Oct 11:1-7. doi: 10.1080/09273948.2017.1370650.	CVI provides insight into structural changes in choroid in TB MSC. During the active disease, there is relative decrease in choroidal vascularity. As the lesions heal, choriocapillaris atrophy occurs with remodeling of choroid.
Response to systemic corticosteroids in VKH disease Jaisankar D, Raman R, Sharma HR, Khandelwal N, Bhende M, Agrawal R, Sudharshan S, Biswas J. **Choroidal and Retinal Anatomical Responses Following Systemic Corticosteroid Therapy in Vogt-Koyanagi-Harada Disease Using Swept-Source Optical Coherence Tomography.** *Ocul Immunol Inflamm*. 2017 Jul 12:1-9. doi: 10.1080/09273948.2017.1332231	Mean CT significantly improved from 83.1±8.75 to 156.4±62.73µm (p = 0.008) in the zone with pre-CT <100µm and significantly decreased from 336.1 ± 17.28 to 266.28 ± 81.39µm(p = 0.008) in the zone with pre-CT > 300µm. We have shown choroidal remodeling in VKH. SS-OCT can serve as an important noninvasive tool in assessment of treatment response in patients with VKH disease.

CVI in surgery

Vitrectomy Rizzo, S. Savastano, A. , Finocchio, L. , Savastano, M. C., Khandelwal, N. and Agrawal, R. (2018), **Choroidal vascularity index changes after vitreomacular surgery.** Acta Ophthalmol, 96: e950-e955. doi:10.1111/aos.13776	CVI was higher in vitrectomy group, possible due to the retinal traction and distortion from epiretinal membrane which affected the choroid. CVI decreased in operated eye following vitrectomy because vitrectomy reduces traction and VEGF, thereby reducing the choroid's vascular area.
Phacoemulsification Chen, H., Wu, Z., Chen, Y., He, M., & Wang, J. (2018). **Short-term changes of choroidal vascular structures after phacoemulsification surgery**. BMC Ophthalmology, 18(1). doi:10.1186/s12886-018-0749-7	Phacoemulsification induced increased CVI in patients diagnosed with cataract. Evaluation of the long-term change of CVI following surgery may provide valuable information for studying the relationship between phacoemulsification and disorders of the choroid.

For further enquiry, please contact
A/Prof. Rupesh Agrawal (rupeshttsh@gmail.com)
Mr. Ding Jianbin (dingjianbin97@gmail.com)
Mrs. Neha Khandelwal (nehattsh@gmail.com)
Or visit www.cvigrid.org